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Dutch National Mastitis Survey. The value of bulk milk cell counts in diagnosing bovine mastitis

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Summary

Bulk milk samples of 227 at random selected herds and quarter milk samples of 10336 cows of these herds were collected once. Bulk milk somatic cell counts (BMSCCs), which are estimated every four weeks, being part of the Dutch Milk Quality Control Programme, were used to calculate three derivative cell counts: the C3 count, the C13 count and the C18 count. The correlation of these counts with the prevalence of mastitis in herds was determined. Correlation coefficients varied from 0.42 to 0.62. BMSCC and the C3 were neither highly sensitive (maximum sensitivity 75 %) nor predictive (maximum predictive value 70 %) in identifying herds with a high prevalence of mastitis. At the cell count threshold C = 500, 55-76 % herds with a high prevalence of subclinical mastitis were not detected by the C3. Thirty-six percent of the herds with a C3 exceeding the threshold of C = 500 and 42 % of the herds with a C3 exceeding the threshold of C = 400 could not be classified as mastitis problem herds. Both BMSCC and C3 had higher sensitivity but lower specificity and predictive value at a threshold of C = 400 than at the threshold of C = 500. BMSCC and the C3 could reasonably specifically (84-99 %) diagnose herds with a low prevalence of mastitis. Because of their low sensitivity and predictive value it would not be justified to assume a high prevalence of subclinical mastitis on farms based on BMSCC and the C3, without further evidence. Direct bulk milk cell counts and their derivatives appeared unsuitable in determining the prevalence of mastitis in individual herds.

1 Introduction

Assessment of bulk milk somatic cell count (BMSCC) is part of the Dutch Milk Quality Control Programme. The European Community (EC) has recently accepted uniform regulations for trade of heat-treated milk within its member countries. Hence the standard for BMSCC of individual dairy herds in the Netherlands has been changed from 750 (in thousands/ml) to 500. This might lead to exclusion for further delivery of milk from farms that repeatedly do not meet the new standard. A reduction in the prevalence of mastitis might be an advantage of such legislation. Therefore the value of BMSCC and derivatives for determining the prevalence of subclinical mastitis in herds was studied as part of the Dutch national mastitis survey.

2 Materials and methods

Bulk milk samples of 227 at random selected dairy herds and quarter milk samples of 10 336 cows of these herds were collected. Somatic cell count (SCC) of bulk milk samples, and SCC and pathogens in quarter milk samples were determined according to standard methods (1). From the data of the twelve last BMSCCs — assessed by the Central Organization for Milk Hygiene — we calculated three derivatives of the BMSCC: the C3, C13 and C18 (see Table 1 for definitions) and called these mastitis keys. To evaluate these mastitis keys as a tool for diagnosing mastitis, the rank correlations according to Spearman's coefficient between the four types of mastitis keys (BMSCC, C3, C13 and C18), and four mastitis parameters were determined.

The BMSCC and the C3 were examined at different threshold values for cell count — C = 400, C = 500 and C = 750 (in thousands/ml) — for their reliability in identifying herds with a high and a low prevalence of subclinical mastitis. Herds with either ≥ 10 % or ≥ 16 % mastitic quarters were considered high-prevalence ('problem') herds, hence two definitions of problem herds were used. The latest recommendation of the International Dairy Federation for defining subclinical mastitis was followed (2): quarter milk was considered mastitic when bacteriological examination revealed udder pathogens and SCC was ≥ 250 (compared to $C \geq 500$ in the classical definition). BMSCC and C3 were also examined with the classical definition of subclinical mastitis. With these definitions we classified the results of BMSCC and the C3 as true positives (TP), false positives (FP), true negatives (TN), and false negatives (FN). The sensitivity, specificity and predictive value of the BMSCC and the C3 were calculated. Sensitivity was determined as the proportion of problem herds, correctly identified: TP/(TP + FN). Specificity was determined as the proportion of normal herds correctly identified: TN/(TN + FP). Predictive value was determined as the proportion of correctly identified problem herds of all the positive results: TP/(TP + FP).

3 Results and discussion

Herds were classified by BMSCC and number of lactating cows. In 1980, high BMSCCs were often observed in small herds, and low BMSCCs in large herds (Fig. 1), whereas in 1985 BMSCC and herd size did not correlate. Rank correlations of BMSCC and its derivatives with prevalence of subclinical mastitis varied from 0.42 to 0.62 (Table 1). Rank correlations of the C18, although slightly higher than those of the BMSCC, C3 and C13, were still low. Rank correlations of BMSCC and derivatives with prevalence of quarters with

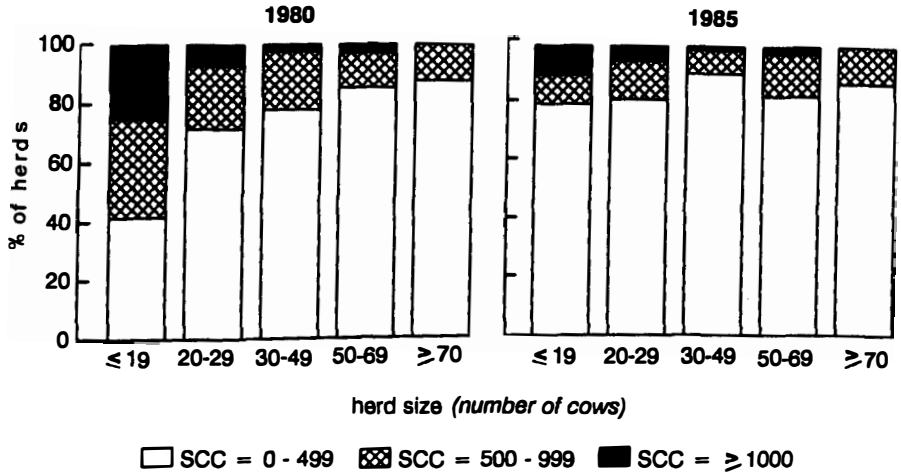

Fig. 1. Distribution of BMSCC in relation to herd sizes.

Table 1. Rank correlations of BMSCC and three derivative cell counts (mastitis keys) with six mastitis parameters.

	BE+[a]	Mastitis parameters				
		C≥250[b]	C≥500[c]	BE+,C≥250	BE+,C≥500	C≥1000[d]
BMSCC[e]	0.36	0.43	0.50	0.42	0.49	0.56
C 3[f]	0.52	0.53	0.59	0.59	0.59	0.65
C 13[g]	0.54	nd[h]	0.59	nd	0.62	0.64
C 18[i]	0.55	0.54	0.61	0.62	0.63	0.66

[a] BE+ = positive bacterial examination.
[b] C≥250 = cell count more than 250 000/ml.
[c] C≥500 = cell count more than 500 000/ml.
[d] C≥1000 = cell count more than 1 000 000/ml.
[e] BMSCC = bulk milk cell count.
[f] C3 = the geometric mean of the 3 most recent BMSCCs.
[g] C13 = the geometric mean of the 13 most recent BMSCCs.
[h] nd = not done.
[i] C18 = the geometric mean of the 13 most recent BMSCCs, with a weight factor 1 for the first 13 counts and a weight factor 5 for the geometric mean of the last 3 counts.

C≥500 were higher than that with prevalence of quarters with C≥250. Many studies have correlated BMSCC with mean cow SCC and found — predictably — high correlations. Fewer studies have related BMSCC with prevalence of

Table 2. Sensitivity, specificity and predictive value (%) of BMSCC as a herd test for mastitis diagnosis.

	BMSCC					
	C = 400		C = 500		C = 750	
'true status'[a]	M ≥ 10	M ≥ 16 %	M ≥ 10	M ≥ 16 %	M ≥ 10	M ≥ 16%
Sensitivity (%)	41 (56)[b]	75 (20)	30 (56)	65 (20)	13 (56)	25 (20)
Specificity (%)	84 (158)	83 (194)	92 (158)	92 (194)	98 (158)	97 (194)
Predictive value (%)	47 (49)	31 (49)	59 (29)	45 (29)	70 (10)	50 (10)

[a] Herds with ≥ 10 % or ≥ 16 % subclinical mastitis (M) quarters (i.e. milk has a somatic cell count ≥ 250 000 cells/ml and contains udder pathogens).
[b] The number of herds in each group is given in brackets.

mastitis in cows. Such studies showed low correlations (3, 4, 5, 6, 7, 8). Especially, udder infections by *Staphylococcus aureus* and *Streptococcus uberis* are often associated with low (0-500) SCC in quarter milk (9). This partly explains the low correlations of cell counts of bulk milk with prevalence of infected quarters.

Because the Dutch Milk Quality Control Programme uses the BMSCC and because the EC regulations refer to herd milk samples of the three most recent months, we evaluated sensitivity, specificity and predictive value of the BMSCC and the C3 (Tables 2 and 3).

Sensitivity of the BMSCC and C3 at the threshold of C = 750 was very low: 3-25 %. The highest sensitivity, 75 % (15 out of 20), was observed for the BMSCC at a threshold value C = 400, ('true status' M ≥ 16 %, Table 2). Un-

Table 3. Sensitivity, specificity and predictive value (%) of C3 as a herd test for mastitis diagnosis.

	C3					
	C = 400		C = 500		C = 750	
'true status'[a]	M ≥ 10	M ≥ 16 %	M ≥ 10	M ≥ 16 %	M ≥ 10	M ≥ 16%
Sensitivity (%)	48 (59)[b]	75 (20)	24 (59)	45 (20)	3 (59)	5 (20)
Specificity (%)	88 (168)	84 (207)	95 (168)	94 (207)	99 (168)	99 (207)
Predictive value (%)	58 (48)	31 (48)	64 (22)	41 (22)	50 (4)	25 (4)

[a] Herds with ≥ 10 % or ≥ 16 % subclinical mastitic (M) quarters (i.e. milk has a somatic cell count ≥ 250 000 cells/ml and contains udder pathogens).
[b] The number of herds in each group is given in brackets.

fortunately, this coincided with a very low predictive value: 31 %. At the threshold C = 500, 55-76 % herds with a high prevalence of subclinical mastitis were not detected by the C3. Besides, recent research has also shown high frequency of clinical mastitis by environmental pathogens in some herds with low BMSCC (10, 11).

The highest predictive value for the BMSCC at a threshold C = 750 ('true status' M ≥ 10 %, Table 2) was 70 % (7/10). This predictive value coincided with a very low sensitivity: 3 %. At thresholds C = 400 and C = 500, the predictive values of BMSCC and C3 were low: 31-64 %. At threshold C = 500, 36 % of the herds indicated by the C3 had less than 10 % mastitic quarters. At threshold C = 400 this percentage rose to 42 %. The high proportion (ca 60-70 %) of quarter milk samples that have a SCC ≥ 500 and yet are bacteriologically negative (3, 4, 8) may cause false positive results and hence explain the low predictive value. Wanasinghe & Frost (12) found 36 % non-infected quarters in quarter milk from herds with a high Wisconsin Mastitis Test (WMT) score, ≥ 10 (~C ≥ 500), and 28 % infected quarters in herds with a low WMT score, <10 (~C<500). They stated 'it seems unsound to use these counts as an assessment of the mastitis status and of the progress of control in individual herds without further evidence'. Our data show that the same applies to the use of BMSCC and its derivatives. Besides, SCC increases with parity and stage of lactation (9). Therefore, herds with a high proportion of older cows at the end of their lactation will have a relatively high BMSCC. Small herds have a greater chance of an uneven distribution of parity and stage of lactation. Therefore, they may exceed the thresholds of C = 400 or C = 500 without actually being a problem herd.

In this survey both the BMSCC and the C3 proved reasonably specific. Depending on the definitions of problem herd and the cell count thresholds, 84-99 % of the normal herds were correctly indicated.

Instead of the classical definition of subclinical mastitis used previously (3, 4, 8, 9) we followed the latest recommendation of the International Dairy Federation for defining subclinical mastitis. The implications for sensitivity, specificity and predictive value were minor: with the 'new' definition both BMSCC and C3 had lower sensitivity (ca −10 %), similar specificity and higher predictive value (ca +10 %).

This study shows that BMSCC and derivatives such as the C3 are unreliable indicators of a high prevalence of mastitis in herds. It would not be justified to exclude farms from milk delivery, on the basis of cell counts of tank milk only, because such counts may give a misleading indication of a high prevalence of subclinical mastitis.

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